Association of Insects and Ergot (*Claviceps purpurea*) in Kentucky Bluegrass Seed Production Fields

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ABSTRACT Insects in Kentucky bluegrass seed production fields in Oregon, Iaho, and Washington were sampled just before harvest and their association with ergot conidia of *Claviceps purpurea* Fr. (Tul.) was evaluated during 1996–1998. A diversity of insects was observed at all three locations. The most abundant beneficial insects collected with sweep nets were *Nysium* spp., *Nabis* spp., ichneumonid wasps, and *Hippodamia* spp. The cranberry girdler, *Chrysoteuchia topiaria* (Zeller), was the only important pest on grass seed collected by sweep net. Numbers of aphids such as *Sitobion avenae* (F.), cicadellids and thrips such as *Anaphothrips* spp. and *Aptinothrips* spp. that were collected with an aphid sampler were below economic thresholds. Other insect groups occurred in low numbers. Noctuid moths collected in universal blacklight traps included nine species of cutworms and armyworms. *Protagrotis obscura* (B. & McD.) was the most common cutworm species and was present in all fields. The moth *Chortodes rufostrigata* (Pack.) previously reported only from wet meadows in northeast and south central Oregon was found in Kentucky bluegrass fields in central Oregon, suggesting that irrigated Kentucky bluegrass seed production fields may simulate a montane meadow habitat. Conidia of *C. purpurea* were found on a diversity of insects, including moths, flies, leafhoppers, and thrips. Up to 100% of moths and 75% of flies collected from some fields carried conidia of *C. purpurea.* No correlation between ergot honeydew present in a field and number of insects with conidia of *C. purpurea* was detected.

KEY WORDS *Claviceps purpurea*, *Poa pratensis*, *Chortodes rufostrigata*, grass seed, insect samples, disease samples

KENTUCKY BLUEGRASS (*Poa pratensis* L.) seed is produced on nearly 100,000 acres in the Pacific Northwest. The major production areas include the Grande Ronde Valley near La Grande and Elgin, OR; the Rathdrum Prairie between Spokane, WA, and Coeur d'Alene, ID; and central Oregon surrounding Madras and Culver, OR. Kentucky bluegrass fields are generally planted in April, May, or August in the Grand Ronde Valley, the Rathdrum Prairie, and central Oregon, respectively. The grass is grown as a perennial for 3–5 yr. All three areas are semiarid and fields are irrigated. Harvest of Kentucky bluegrass seed in all areas begins about the first of July. Postharvest residue management in Oregon generally includes thermal treatment such as open field burning or treatment with large propane burners.

Winter grain mite, *Penthaleus major* (Dugès), can cause severe damage in Kentucky bluegrass fields by feeding on plants through the winter months and is the primary pest in the Grande Ronde Valley and central Oregon.

The cranberry girdler is a well-known pest of grasses in the Pacific Northwest (Crawford and Harwood 1959, Kamm 1971a), and is considered the most severe pest on bluegrasses and creeping fescue in northeast Washington (Harwood 1958). The cutworm *Protagrotis obscura* B. & McD is a major pest of grasses grown for seed in the Pacific Northwest, and specifically in the Grande Ronde Valley (Kamm 1982). *Crymodes devastator* (Brace) was found in large numbers near Spokane in a previous survey of grass seed fields (Crawford and Harwood 1959). It is considered the primary cutworm pest in that area (Harwood 1958). Cutworm damage frequently occurs in fall and may continue through winter and into spring. Populations of cranberry girdlers and cutworms increase in grass seed fields as temperatures warm in the spring, and both can cause significant damage by feeding on the crowns of developing plants (Kamm 1982).

Silvertop on Kentucky bluegrass prevents the production of viable seeds on affected panicles. Thrips such as *Anaphotrips obscurus* (Müller) have been identified as a cause of silvertop (Kamm 1971b), as have larval Chloropidae (Starks and Thurston 1962). Grass seed fields are occasionally treated for control of *Anaphothrips* spp. and *Aptinothrips* spp., and other potential pests such as cicadellids and *Sitobion avenae* (F.). The grass bug *Labops hesperius* (Uhler) is considered a minor pest, but has caused serious damage to grass leaves in seed fields near Spokane (Harwood 1918).

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In addition to insect pests, Kentucky bluegrass is often infected by the fungal plant pathogen *Claviceps purpurea* Fr. (Tul.) (Alderman et al. 1998). Seed is replaced with a hard black sclerotium about one to four times larger than the host seed (Alderman 1991). Both the disease and the sclerotium are commonly referred to as ergot (Bove 1970). During infection of grass flowers, plant sap containing a large number of conidia of *C. purpurea* exudes from infected florets (Luttrell 1980). The exudate is commonly referred to as "honeydew" because it has a high sugar content (Barger 1931, Bove 1970, Mower and Hancock 1975). Insects are attracted to the honeydew and are believed to play a role in the dissemination of *C. purpurea* (Atanasoff, 1920, Moreno et al. 1971, Ingold and Plunkett 1979, Lemon 1992). However, the association of ergot and insects in Kentucky bluegrass seed production has not been investigated.

The objectives of this study were to determine what insects are present just before harvest in Kentucky bluegrass seed production fields in the Pacific Northwest and to determine if conidia of *C. purpurea* are commonly associated with these insects. This study was not designed as a quantitative survey.

Materials and Methods

Insects were sampled in Kentucky bluegrass fields from the Rathdrum Prairie, ID; central Oregon; and the Grande Ronde Valley, OR, during 1996–1998. Three Kentucky bluegrass seed fields in each of the three regions were sampled during 1996 and 1997, and two fields rather than three from two of the regions in 1998 due to reduced funding. Varieties sampled on the Rathdrum Prairie were 'Shamrock', 'Midnight', and 'Plush' each year. In central Oregon 'Coventry' and 'Gnome' were sampled in 1996; 'Coventry', 'Georgetown', and 'Merit' in 1997; and 'Georgetown' and 'Coventry' in 1998. In the Grande Ronde Valley the varieties sampled included 'Bristol' and 'Coventry' in 1996; 'Sidekick', 'Nassau', and 'Ascot' in 1997; and 'Fairfax' and 'Nassau' in 1998. Fields were sampled 1 wk or less before harvest to maximize the presence of ergot sclerotia and honeydew.

Insect Collection and Identification. Insects were sampled with a sweep net, an aphid sampler (Gray and Schuh 1941), and universal blacklight traps. Insect sweeps were taken with a 380-mm sweep net. Twenty straight-line sweeps 2.5 m long covering a 1-m^2 area were taken in each of the four quadrants of each field. A representative series of individuals of each insect collected was pinned and identified with the location and date of collection.

The aphid sampler was used to collect small insects from grass heads and foliage. The aphid sampler is a cylinder (40 cm diameter by 50 cm) with a handle on each side near the lid for shaking. Grass foliage from a 0.2-m^2 area was randomly collected from each of four quadrants of each field. Samples were immediately placed on the 6-mm mesh screen inside the shaker, exposed to methyl ethyl ketone placed on a gauze pad on the underside of the lid and shaken to release the insects from the foliage. After dropping through the screen, insects dropped down a funnel-shaped base to a 0.5-liter collecting jar at the bottom. Insects collected in the jar were transferred to 23 by 85-mm vials containing 95% ethyl alcohol. Insects were identified, and the number of each insect taxa collected was recorded.

Moths were sampled with a single universal blacklight trap placed 30 m from the edge of each field at dusk and insects were collected the following morning. A Bio-Strip 6 by 16-cm fumigant strip impregnated with DDVP (Bio-Strip, Reno, NV) was placed in the bottom of the traps to kill the moths. Moths were placed in 4-liter zip-lock bags and refrigerated until placed in a freezer. They were later thawed, mounted, and identified.

Ergot Insect Associations. To determine insects associated with *C. purpurea*, a second collection was made at each site using a modified sweep net and aphid sampler. Sticky cards were used to prevent cross contamination and enable individual insects to be evaluated for the presence of ergot conidia. The sweep net was modified with a sticky card mounted at the end of a handle (1 m long by 25 mm diameter) and enclosed in a 6-mm mesh hardware cloth cylinder 25 cm in diameter. Insects passed through the mesh and were collected on the sticky card, permitting sweeps to be taken without contamination by honeydew. The modified aphid sampler had a sticky card placed in the bottom of a straight-sided 20-liter plastic bucket rather than the traditional funnel-shaped base with a collecting jar at the bottom. This allowed individual insects to fall directly onto the sticky card. For moth collection, two sticky cards were attached to the outer edge of the universal blacklight trap so individuals could be collected as they first approached the light.

For ergot assessment, a drop of water was placed on the mouthparts of insects to wash off any adhering conidia. After 15 s the drop was removed, mounted on a glass slide and examined under 200× magnification. Conidia of *C. purpurea* were identified based on comparison with known conidia collected from naturally infected flowers. Because species identification on sticky cards was difficult, insect identification to the species level was not attempted.

Grass seed heads were collected during 1997 and 1998 to determine the presence of honeydew and ergot sclerotia. Using a finger knife 100 panicle samples of grass were randomly collected by hand from a single 5,000-m^2 area in each of the fields during 1997 and 1998 to determine the level of honeydew and ergot sclerotia present in each field. After samples were air-dried, the total number of sclerotia per sample, the percent of panicles with honeydew, and the percent of panicles with sclerotia were recorded.

Insect collections using the aphid sampler, where replicated quantitative data were generated, were analyzed using analysis of variance to test for differences in the number of insects collected from each geographic area by year with CoStat (Cohort Software 1995). Separation of means was determined using the Student-Neuman-Keuls test ($P \leq 0.05$).

Table 1. Number of fields in which each taxa were collected with a sweep net

	Rathdrum Prairie, ID			Central Oregon, OR			Grande Ronde Valley, OR		
	1996 3 fields	1997 3 fields	1998 3 fields	1996 3 fields	1997 3 fields	1998 2 fields	1996 3 fields	1997 3 fields	1998 2 fields
Beneficial predators and parasites									
Coleoptera									
Carabidae	0	0	1	0	0	0	0	0	0
Coccinellidae	2	2	2	3	1	2	0	1	1
Staphylinidae	0	0	0	1	0	0	0	0	1
Hemiptera									
Anthocoridae	0	2	0	0	0	0	0	0	0
Lygaeidae	3	1	3	3	2	2	3	3	2
Nabidae	3	0	2	3	3	2	3	2	2
Hymenoptera									
Braconidae	2	0	0	1	0	1	2	0	0
Ichneumonidae	1	3	3	1	3	1	2	3	3
Neuroptera									
Chrysopidae	0	0	0	1	0	0	0	0	0
Odonta									
Coenagrionidae	0	0	0	1	0	0	0	1	0
Common pests on grass seed									
Lepidoptera									
Pyralidae	3	3	3	2	1	0	1	1	3
Casual visitors/Pests on other crops									
Coleoptera									
Bruchidae	0	0	1	0	0	0	0	0	0
Chrysomelidae	0	1	0	0	0	0	1	2	1
Diptera	3	3	3	3	3	2	3	3	2
Hemiptera									
Miridae									
Calocoris	0	0	1	0	0	0	0	0	0
Hoplomachus	2	3	2	0	0	0	0	0	0
Lygus	2	0	0	1	1	0	0	1	0
Megaloceroea	1	3	1	1	0	0	0	1	0
Monosynamma	1	3	3	0	0	0	1	1	0
Stenodema	0	2	0	0	0	0	0	3	1
Hemiptera									
Pentatomidae	0	2	1	0	0	0	0	0	0
Rhopalidae	0	0	0	2	0	0	1	0	0
Scutelleridae	2	2	3	0	0	0	0	2	1
Homoptera									
Cercopidae	0	1	3	0	1	0	0	0	1
Delphacidae	0	0	2	1	2	1	1	1	1
Orthoptera									
Acrididae	2	0	0	0	0	1	2	0	1

Results

Of the 30 taxa of insects collected in sweep nets and the aphid sampler, 10 were beneficial, four were pests or potential pests on grass seed, and 15 were classified as casual visitors or pests on other crops (Table 1). Beneficial predators included *Hippodamia* spp., *Orius tristicolor* (White), *Nysius* spp., *Nabis* spp., and *Chrysoperla plurabunda* (Fitch). Parasitic insects included braconid and ichneumonid wasps. Pests or potential pests on Kentucky bluegrass grass included the cranberry girdler, aphids, thrips, and leafhoppers.

The most abundant beneficial insects collected in sweep nets across the three regions were big-eyed bugs, damsel bugs, ichneumonid wasps, and lady beetles. The cranberry girdler was the only serious insect pest on grasses that was collected from all three geographical locations.

The average number of aphids, leafhoppers, and thrips collected from grass foliage samples in the aphid sampler were relatively low across locations and years (Table 2). Leafhoppers and thrips were collected in the greatest numbers on the Rathdrum Prairie, thrips were most common in central Oregon, and low numbers of aphids, leafhoppers, and thrips were collected in the Grande Ronde Valley. When analyzed statistically for location by year, the number of aphids was generally less (at $P \leq 0.05$) than leafhoppers or thrips.

Night flying moths included cutworms and armyworms (Table 3). *Protagrotis obscura* B. & McD was the most common cutworm species of those known to be pests in grasses grown for seed, and was present in all fields sampled. In addition, *Agroperina dubitans* (Walker) was common in Idaho, whereas *Crymodes devastator* (Brace) was most common in samples collected from the Oregon sites.

The amount of ergot sclerotia and honeydew varied among fields (Table 4). The number of sclerotia per 100 panicles ranged from 0 to 565 and ergot was found in all fields except on the variety Georgetown in 1998 (Table 4). Conidia of *C. purpurea* were found on a high

Table 2. Average number of insects per sample from Kentucky bluegrass foliage extracted in sampling can

	No. of individuals collected per sample ± SE								
	Rathdrum Prairie, ID			Central Oregon, OR			Grande Ronde Valley, OR		
	1996 3 fields	1997 3 fields	1998 3 fields	1996 3 fields	1997 3 fields	1998 2 fields	1996 3 fields	1997 3 fields	1998 2 fields
Homoptera									
Aphididae	0.8b ± 1.7	1.6b ± 3.3	1.2b ± 1.9	1.1 ± 1.2	4.6 ± 6.0	1.8b ± 0.7	2.5ab ± 3.3	0.9b ± 1.0	2.5b ± 2.7
Cicadellidae	6.7a ± 9.6	37.3a ± 36.0	15.5a ± 12.0	1.1 ± 1.0	4.0 ± 4.3	1.1b ± 0.8	4.7a ± 5.4	24.1ab ± 15.8	5.8b ± 3.7
Thysanoptera									
Thripidae	1.1b ± 2.1	25.1a ± 14.3	13.8a ± 10.3	0.5 ± 0.8	40.3 ± 80.7	30.1a ± 34.7	0.1b ± 0.3	48.3a ± 63.4	184.1a ± 242.3
				NS	NS				

Values are the means ± SE based on four samples of grass foliage from 0.2-m^2 areas per field, times the number of fields sampled per year. Means within a column followed by the same letter are not significantly different ($P \leq 0.05$, Student-Newman-Keuls test).

percentage (67–100%) of moths (Table 4). Conidia were also found on flies, leafhoppers, and thrips. A relationship between the presence of ergot in a field and percentage of moths, flies, leafhoppers, or thrips with conidia of *C. purpurea* was not established.

Discussion

A diverse assemblage of insects was collected in grass fields at all three locations (Table 1). The majority of insects were collected using the sweep net. However, aphids, thrips and leafhoppers were collected more effectively using the aphid sampler, and moths other than the cranberry girdler, were collected at night with the universal blacklight traps.

Results from this study suggest that the winter grain mite, cutworms and the cranberry girdler may be important pests on grass fields in the Grande Ronde Valley. The winter grain mite is the major pest in central Oregon, with the cranberry girdler only occasionally reaching treatable levels. On the Rathdrum Prairie, the cranberry girdler is considered the only major insect pest.

Aphids were not found to be an economically important pest during the course of this study (Table 2), but *Sitobion avenae* (F.) was found in fields from all three regions. Although not normally considered a pest of grasses, this aphid can cause economic injury to cereals in some years.

Anaphothrips spp. and *Aptinothrips* spp. appeared to be the most common genera of thrips collected. Both can cause silver top symptoms when populations feed within the "boot" as the seed head is developing. However, numbers collected from the different fields were generally low (Table 2) compared with numbers collected in bent grasses and fine fescue grasses of western Oregon (Kamm 1971b) and appeared to be of little significance. *Stenodema* spp. are also known to cause silver top (Arnott and Bergis 1967) and were collected in low numbers on the Rathdrum Prairie and the in Grand Ronde Valley, but were absent from central Oregon samples. Silver top was not a problem in the fields sampled, but has been reported to occur in Kentucky bluegrass in the Northwest.

Flies were the only casual visitor or pest on other crops that were consistently found in Kentucky bluegrass across the three regions in any significant number. Other insects considered casual visitors or noncrop pests included grasshoppers, seed and leaf beetles, and a variety of plant bugs.

Diversity of night flying moths varied substantially between the Rathdrum Prairie, central Oregon and the Grande Ronde Valley (Table 3). *A. dubitans* and *P. obscura* were collected from every field on the Rathdrum Prairie, whereas *C. devastator* was found in only one field. In Oregon, nine species of grass feeding moths were collected; six in central Oregon and eight in the Grande Ronde Valley (Table 3). Common species in Oregon included *C. devastator*, *Aletia oxygala* (Grote), and *Leucania farcta* Grote. Of the species collected, *P. obscura*, *A. dubitans*, *Agroperina lateritia* (Hufnagel), *Apamea amputatrix* (Fitch) and *C. devastator* are soil-surface feeding cutworms, whereas *A. oxygala* and *L. farcta* are climbing cutworms, often

Table 3. Number of fields in which each species of grass feeding noctuids were collected in black light traps

	Rathdrum Prairie, ID			Central Oregon, OR			Grande Ronde Valley, OR		
	1996 2 fields	1997 3 fields	1998 3 fields	1996 1 field	1997 3 fields	1998 2 fields	1996 2 fields	1997 3 fields	1998 2 fields
Agroperina dubitans	2	3	3	0	0	0	1	0	0
Agroperina lateritia	0	0	0	0	0	0	1	0	0
Aletia oxygala	0	0	0	1	0	0	2	2	2
Apamea alia	0	0	0	0	0	0	0	0	1
Apamea amputatrix	0	0	0	0	0	1	2	1	0
Chortodes rufostrigata	0	0	0	0	0	2	0	0	0
Crymodes devastator	0	0	1	1	2	2	1	1	0
Leucania farcta	0	0	0	1	1	1	1	0	0
Protagrotis obscura	2	3	3	1	3	2	2	3	2

Table 4. Association of *C. purpurea* with various insects collected from Kentucky bluegrass fields during 1997 and 1998 and level of ergot present in the fields

	Sclerotia per 100 panicles[a]	Percent panicles		% of insects with *C. purpurea* conidia							
				Moths		Flies		Leafhoppers		Thrips	
		Sclerotia	Honeydew	%	Total[b]	%	Total[b]	%	Total[b]	%	Total[b]
Rathdrum Prairie, ID											
1997											
'Shamrock'	20	12	7	67	(6)[2]	75	(4)	19	(505)	14	(28)
'Plush'	65	26	32	80	(10)	63	(8)	60	(216)	32	(142)
'Midnight'	151	55	0	81	(16)	35	(23)	13	(15)	6	(66)
1998											
'Shamrock'	27	15	6	100	(16)	74	(19)	20	(329)	10	(99)
'Plush'	18	9	2	91	(11)	57	(37)	25	(188)	16	(108)
'Midnight'	88	33	4	67	(6)	24	(37)	7	(59)	3	(97)
Central Oregon											
1997											
'Coventry'	212	51	4	100	(3)	52	(23)	—	—	17	(6)
'Merit'	122	49	64	100	(16)	69	(70)	42	(12)	34	(29)
'Georgetown'	3	1	0	—	—	11	(9)	0	(15)	3	(96)
1998											
'Coventry'	565	87	0	67	(15)	37	(402)	4	(24)	4	(237)
'Georgetown'	0	0	0	40	(5)	19	(32)	—	—	6	(17)
Grand Ronde Valley											
1997											
'Ascot'	42	21	1	89	(66)	73	(15)	57	(28)	31	(39)
'Nassau'	82	31	22	84	(37)	14	(7)	10	(51)	0	(2)
'Sidekick'	4	2	0	100	(31)	60	(5)	39	(28)	6	(16)
1998											
'Fairfax'	206	73	30	87	(31)	77	(160)	51	(69)	16	(318)
'Nassau'	12	8	1	43	(14)	32	(327)	22	(68)	8	(247)

[a] Number of sclerotia based on single 100-panicle sample per field.
[b] Total number of individuals examined.

feeding on flower inflorescences and seed heads (Crumb 1956, Kamm 1982). Only soil-surface feeding cutworms were found at the Idaho site, and they also were most abundant in all Oregon sites (Table 3). Climbing cutworm species appeared to be less common in Kentucky bluegrass fields.

The moth *Chortodes rufostrigata* which was collected in fields at both central Oregon locations during 1998 had only previously been collected in wet meadows in the Blue and Wallowa Mountains of northeast Oregon, and one isolated record from Lake County in south central Oregon. Both the central Oregon locations are new county records and significant range extensions for this species within Oregon. Quite possibly the irrigation of the bluegrass fields duplicates the normal wet meadow habitat of this species, allowing a naturally very rare species that inhabits montane meadows to invade and successfully establish in irrigated grass seed fields.

The level of ergot varied greatly among fields of Kentucky bluegrass. Varietal susceptibility is considered an important factor in disease severity, as well as soil moisture content during flowering. More susceptible varieties generally have a longer flowering period, thereby increasing their chance for infection during anthesis. A relationship between ergot honeydew present in a field and number of insects with *C. purpurea* conidia was not established, suggesting that the level of ergot is independent of insect diversity and populations within a field. Presence of honeydew can vary depending on rainfall or irrigation because water from these sources can wash honeydew off the panicles. Although ergot was not detected in the cultivar Georgetown in 1998, it was likely present in the field but below the level of detection (100 panicles) used in this study. All Kentucky bluegrass fields sampled were in areas of Kentucky bluegrass seed production where ergot was common. It is possible that flying insects such as moths and flies could have carried conidia from one field to another. However, it is not known how persistent conidia would be on the mouthparts of insects.

Condia were found on a high percentage of moths. Moreno et al. (1971) reported a similar high occurrence of *C. purpurea* on the cabbage looper moth *Trichoplusia ni* (Hubner) in North Dakota. Flies are generally known to be attracted to ergot honeydew (Atanasoff 1920, Barger 1931, Ingold and Plunkett 1979, Lemon 1992) and results from this study confirm a high percentage of flies within a field can carry conidia. Because of its high sugar content, honeydew from ergot infection may represent an important food source for various moths and flies or other insects attracted to the sugars. Hardy (1988) reported feeding by *Polistes* spp. on honeydew of *Claviceps.* Although flies and moths were associated with a high level of ergot, it is not clear how efficient the insects are in vectoring conidia of *C. purpurea* from infected to healthy flowers.

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References Cited

Alderman, S. C. 1991. Aerobiology of *Claviceps purpurea* in Kentucky bluegrass. Plant Dis. 75: 1038–1041.

Alderman, S. C., D. D. Coats, F. J. Crowe, and M. D. Butler. 1998. Occurrence and distribution of ergot and estimates of seed loss in Kentucky bluegrass grown for seed in central Oregon. Plant Dis. 82: 89–93.

Arnott, D. A., and I. Bergis. 1967. Causal agents of silver top and other types of damage in grass seed crops. Can. Entomol. 99: 660–670.

Atanasoff, D. 1920. Ergot of grains and grasses. Stenciled and distributed by USDA Bureau of Plant Industry, Office of Cereal Investigations.

Barger, G. 1931. Ergot and ergotism. Gurney and Jackson, London.

Bove, F. J. 1970. The story of ergot. Karger, Basel.

Cohort Software. 1995. Costat user's manual. Costat, Monterey, CA.

Crawford, C. S., and R. F. Harwood. 1959. Lepidoptera associated with grass grown for seed in eastern Washington. J. Econ. Entomol. 52: 966–969.

Crumb, S. E. 1956. The larvae of the Phalaenidae. U.S. Dep. Agric. Tech. Bull. 1135.

Gray, K. W., and J. Schuh. 1941. A method and contrivance for sampling pea aphid populations. J. Econ. Entomol. 34: 411–415.

Hardy, T. D. 1988. Gathering of fungal honeydew by *Polistes* spp. (Hymenoptera: Vespidae) and potential transmission of the causal ergot fungus. Fla. Entomol. 71: 374–376.

Harwood, R. F. 1958. Suggestions for controlling insects affecting grasses grown for seed. Ext. Bull. E. M. 1918.

Ingold, C. T., and B. E. Plunkett. 1979. An epidemic of *Entolopthora* on flies and its relationship with the sphacelia stage of *Claviceps.* Bull. Br. Mycol. Soc. 13: 35–37.

Kamm, J. A. 1971a. Environmental biology of a sod webworm *Crambus tutillus* (Lepidoptera: Crambidae). Entomol. Exp. Appl. 14: 30–8.

Kamm, J. A. 1971b. Silvertop of bluegrass and bentgrass produced by *Anaphotrips obscurus.* J. Econ. Entomol. 64: 1385–7.

Kamm, J. A. 1982. *Protogrotis obscura* Barnes and McDunnough (Lepidoptera: Noctuidae): a pest of grasses grown for seed in the Pacific Northwest. Pan-Pac. Entomol. 58: 73–8.

Lemon, K. M. 1992. Dispersal of the ergot fungus *Claviceps purpurea* by the lauxaniid fly *Minettia lupulina.* J. N.Y. State Entomol. Soc. 100: 182–184.

Luttrell, E. S. 1980. Host-parasite relationship and development of the ergot sclerotium in *Claviceps purpurea.* Can. J. Bot. 58: 942–958.

Moreno, R., V. D. Pederson, and J. T. Schultz. 1971. Transmission of *Claviceps purpurea* (Fr.) conidia by the cabbage looper moth *Trichoplusia ni* (Hubner). Proc. No. Dak. Acad. Sci. 24: 11–14.

Mower, R. L., and J. G. Hancock. 1975. Sugar composition of ergot honeydews. Can. J. Bot. 53: 2813–2825.

Starks, K. J., and R. Thurston. 1962. Silvertop in bluegrass. J. Econ. Entomol. 55: 865–867.

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